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(71) Applicant: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
1006, Oaza Kadoma
Kadoma-shi, Osaka-fu, 571(JP)

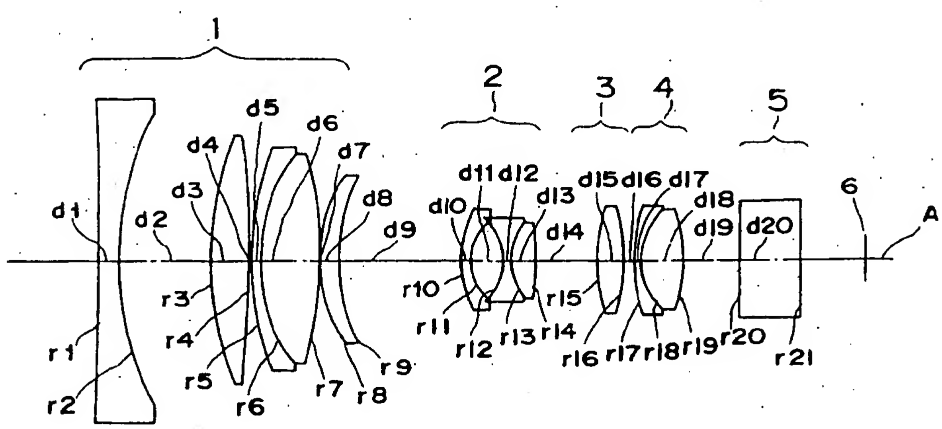
(72) Inventor: **Ono, Shusuke**
31-11, Fukazawahonmachi
Takatsuki-shi, Osaka-fu 569(JP)
Inventor: **Okayama, Hiroaki**
Shokei-Ryo, 4-2, Korigaoka 7-chome
Hirakata-shi, Osaka-fu(JP)

(74) Representative: **Eisenführ, Speiser & Partner**
Martinistrasse 24
W-2800 Bremen 1 (DE)

(54) **Zoom lens.**

(57) A zoom lens for a video camera comprising sequentially from a side of an object: a fixed first lens group (1) constituted by a first concave lens, a first double convex lens, a second concave lens, a second double convex lens and a meniscus convex lens; a movable second lens group (2) constituted by a meniscus concave lens, a double concave lens and a convex lens, a fixed third lens group (3) constituted by a single lens having at least one aspherical surface; and a movable fourth lens group (4) constituted by a concave lens and a convex lens at least one of which has at least one aspherical surface.

Fig. 1



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BACKGROUND OF THE INVENTION

The present invention relates to a high-performance aspherical zoom lens having a wide half angle of view of about 32-35° at a wide angle end and a video camera employing the zoom lens.

In response to recent demand for excellent operational efficiency, good mobility and high image quality in video cameras, high-resolution imaging devices as compact as 1/3" are becoming a mainstream of imaging devices. Meanwhile, in this connection, high-performance and high-magnification zoom lenses which are large in aperture ratio, compact in size and light in weight are in strong demand. Furthermore, due to a big demand for reduction of production cost of zoom lenses, high-performance wide angle zoom lenses in which the number of lens components is reduced are in urgent need.

However, in known wide angle zoom lenses, not only diameters of lenses of a first lens group become large excessively but a large number of lenses are required to be used for for performing more strict aberration correction. As a result, the known wide angle zoom lenses become larger, heavier and more expensive and therefore, have not been suitable for use in video cameras for home use. Therefore, half angle of view of known compact and light zoom lenses having an F-number of about 1.4 to 1.6 and including lenses about 10 to 13 lenses is 25° or less.

Hereinbelow, one example of a prior art zoom lens for use in a video camera disclosed in, for example, U.S. Patent No. 5,100,223 is described with reference to Fig. 2. The prior art zoom lens includes a first lens group 21 acting as an image forming portion, a second lens group 22 acting as a magnification changing portion, a third lens group 23 acting as a light converging portion, a fourth lens group 24 acting as a focusing portion and a glass plate 25 optically equivalent to a quartz crystal filter and a face plate of an imaging device. Reference numeral 26 denotes an image surface.

Operation of the prior art zoom lens of the above described arrangement is described, hereinbelow. The first lens group 21 is fixed relative to the image surface 26 and has an image forming function, while the second lens group 22 is movable on an optical axis A so as to change magnification such that a focal length of an entire system is changed. The third lens-group 23 is fixed relative to the image surface 26 and has a function of converging divergent light produced by the second lens group 22. On the other hand, the fourth lens group 24 is movable on the optical axis A and has a focusing function. Variations in position of the image surface 26 due to travel of the second lens group 22 at the time of zooming are eliminated by displacing the fourth lens group 4 such that the image surface 26 is fixed at a predetermined position.

However, in the prior art zoom lens of the above described arrangement, if it is necessary to raise the half angle of view to 30° or more, it becomes difficult to perform aberration correction especially at a side of wide angle, thereby resulting in a drawback that high image quality cannot over an entire zoom range cannot be achieved.

SUMMARY OF THE INVENTION

Accordingly, an essential object of the present invention is to provide, with a view to eliminating the inconveniences of the prior art, a high-performance wide angle aspherical zoom lens of simple construction having a half angle of view of 30° or more, in which a new lens type and an optical aspherical contour are employed and a video camera employing the wide angle aspherical zoom lens.

In order to accomplish this object of the present invention, a wide angle aspherical zoom lens according to the present invention comprises sequentially from a side of an object: a first lens group which has a positive refracting power and is fixed relative to an image surface; a second lens group which has a negative refracting power and is movable on an optical axis of the wide angle aspherical zoom lens so as to have a magnification changing function; a third lens group which has a positive refracting power and is fixed relative to the image surface so as to have a light converging function; and a fourth lens group which has a positive refracting power and is movable on the optical axis such that the image surface displaceable in response to travel of the second lens group and movement of the object is fixed at a position spaced a predetermined distance from a reference surface; wherein a relatively large air space is provided between the third and fourth lens groups; wherein when viewed sequentially from the side of the object, the first lens group is constituted by a first concave lens, a first double convex lens, a second concave lens, a second double convex lens and a meniscus convex lens, the second lens group is constituted by a meniscus concave lens, a double concave lens and a convex lens, the third lens group is constituted by a single lens having at least one aspherical surface and the fourth lens group is constituted by a concave lens and a convex lens at least one of which has at least one aspherical surface.

The lenses of the first to fourth lens groups have surface contours preferable for excellent aberration performance. To this end, it is preferable in the first lens group that the first concave lens has a concave

surface confronting the image surface, the second concave lens is a meniscus concave lens having a concave surface confronting the image surface and the meniscus convex lens having a concave surface confronting the image surface and that a relatively large air space is provided between the first concave lens and the first double convex lens.

More specifically, the wide angle aspherical zoom lens of the present invention should desirably satisfy the following conditions (1) to (3):

(1) $1.0 < r2/f1 < 3.0$
(2) $1.5 < r3/f1 < 3.5$
(3) $0.2 < d2/f1 < 0.8$

where character f1 denotes a focal length of the first lens group, character r2 denotes a radius of curvature of one surface of the first concave lens of the first lens group, which surface confronts the image surface, character r3 denotes a radius of curvature of one surface of the first double convex lens of the first lens group, which surface confronts the object and character d2 denotes an air space between the first concave lens and the first double convex lens in the first lens group.

Meanwhile, in order to accomplish the object of the present invention, a video camera according to the present invention includes at least the wide angle aspherical zoom lens of the present invention, an imaging device, a signal processing circuit and a viewfinder.

By the above described arrangement of the present invention, the problems inherent in the prior art can be solved. Namely, when viewed sequentially from the side of the object, the first lens group is constituted by the first concave lens, the first double convex lens, the second concave lens, the second double convex lens and the meniscus convex lens, the second lens group is constituted by the meniscus concave lens, the double concave lens and the convex lens, the third lens group is constituted by the single lens having at least one aspherical surface and the fourth lens group is constituted by the concave lens and the convex lens at least one of which has at least one aspherical surface. As a result, the high-performance wide angle aspherical zoom lens having a half angle of view of about 32° or more can be obtained in simple construction.

Meanwhile, when the above conditions (1) to (3) are satisfied, the high-performance wide angle aspherical zoom lens of simple construction in which aberrations are corrected excellently can be obtained.

In addition, by using the wide angle aspherical zoom lens of the present invention, a compact and light video camera having high image quality and a wide shooting range can be obtained.

In accordance with the present invention as is clear from the foregoing, the wide angle aspherical zoom lens having a half angle of view of 32-35°, an F-number of about 1.4 and a zoom ratio of about 8 can be obtained by as small as 11 lens components and the compact, light and high-performance video camera having a wide shooting range can be obtained by using this wide angle aspherical zoom lens.

BRIEF DESCRIPTION OF THE DRAWINGS

This object and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a schematic sectional view of an aspherical zoom lens according to a first embodiment of the present invention;

Fig. 2 is a schematic sectional view of a prior art aspherical zoom lens (already referred to);

Figs. 3(a), 3(b) and 3(c) are diagrams showing spherical aberration, astigmatism and distortion at a wide angle end in the aspherical zoom lens of Fig. 1, respectively;

Figs. 4(a), 4(b) and 4(c) are diagrams showing spherical aberration, astigmatism and distortion at a standard position in the aspherical zoom lens of Fig. 1, respectively;

Figs. 5(a), 5(b) and 5(c) are diagrams showing spherical aberration, astigmatism and distortion at a telephoto end in the aspherical zoom lens of Fig. 1, respectively;

Figs. 6(a), 6(b) and 6(c) are diagrams showing spherical aberration, astigmatism and distortion at a wide angle end in an aspherical zoom lens according to a second embodiment of the present invention;

Figs. 7(a), 7(b) and 7(c) are diagrams showing spherical aberration, astigmatism and distortion at a standard position in the aspherical zoom lens of Fig. 6, respectively;

Figs. 8(a), 8(b) and 8(c) are diagrams showing spherical aberration, astigmatism and distortion at a telephoto end in the aspherical zoom lens of Fig. 6, respectively;

Fig. 9 is a schematic sectional view of an aspherical zoom lens according to a third embodiment of the present invention;

Figs. 10(a), 10(b) and 10(c) are diagrams showing spherical aberration, astigmatism and distortion at a wide angle end in the aspherical zoom lens of Fig. 9;

Figs. 11(a), 11(b) and 11(c) are diagrams showing spherical aberration, astigmatism and distortion at a standard position in the aspherical zoom lens of Fig. 9, respectively;

Figs. 12(a), 12(b) and 12(c) are diagrams showing spherical aberration, astigmatism and distortion at a telephoto end in the aspherical zoom lens of Fig. 9, respectively; and

Fig. 13 is a block diagram showing a video camera according to the present invention, which includes the aspherical zoom lens of the present invention.

In the diagrams of spherical aberration, the solid line, the dotted line and the broken line illustrate d-line, F-line and C-line, respectively, while in the diagrams of astigmatism, the solid line and the dotted line illustrate sagittal image surface and meridional image surface, respectively.

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout several views of the accompanying drawings.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, there is shown in Fig. 1, a wide angle aspherical zoom lens according to a first embodiment of the present invention. The wide angle aspherical zoom lens includes a first lens group having a positive refracting power, a second lens group 2 having a negative refracting power, a third lens group 3 constituted by an aspherical lens having a positive refracting power, a fourth lens group 4 having a positive refracting power and a flat glass plate 5 optically equivalent to a quartz crystal filter and a face plate of an imaging device. Reference numeral 6 denotes an image surface.

The first lens group 1 has an image forming function and is fixed relative to the image surface 6. The second lens group 2 is movable on an optical axis A so as to have a magnification changing function. The third lens group 3 has a light converging function and is fixed relative to the image surface 6. The fourth lens group 4 is movable on the optical axis so as to make focusing adjustments and includes an aspherical lens.

A relatively large air space d16 is provided between the third and fourth lens groups 3 and 4. When viewed sequentially from a side of an object, the first lens group 1 includes a first concave lens, a first double convex lens, a cemented lens composed of a second concave lens and a second double convex lens and a meniscus convex lens, while the second lens group 2 includes a meniscus concave lens and a cemented lens composed of the double concave lens and the convex lens. On the other hand, the third lens group 3 is constituted by a single lens having at least one aspherical surface. Meanwhile, the fourth lens group 4 includes a concave lens and a convex lens at least one of which has at least one aspherical surface.

The requirements that in the first lens group 1, the first concave lens has a concave surface confronting the image surface 6, the second concave lens is a meniscus concave lens having a concave surface confronting the image surface 6 and the meniscus convex lens has a concave surface confronting the image surface 6 and that the relatively large air space d16 is provided between the third and fourth lens groups 3 and 4 are essential for correcting various aberrations of a half angle of view of about 32° or more by using a small number of the lens components.

It is preferable that the wide angle aspherical zoom lens should satisfy the following conditions (1) to (3):

(1) $1.0 < r2/f1 < 3.0$

(2) $1.5 < r3/f1 < 3.5$

(3) $0.2 < d2/f1 < 0.8$

where character f1 denotes a focal length of the first lens group 1, character r2 denotes a radius of curvature of one surface of the first concave lens of the first lens group 1, which surface confronts the image surface 6, character r3 denotes a radius of curvature of one surface of the first double convex lens of the first lens group 1, which surface confronts the object and character d2 denotes an air space between the first concave lens and the first double convex lens in the first lens group 1.

The conditions (1) to (3) are described in more detail, hereinbelow. The condition (1) relates to the radius r2 of curvature of the surface of the first concave lens of the first lens group 1, which surface confronts the image surface 6. The condition (2) relates to the radius of curvature of the surface of the first double convex lens of the first lens group 1, which surface confronts the object. When the ratio (r2/f1) of the condition (1) falls out of the lower limit of 1.0 or the ratio (r3/f1) of the condition (2) falls out of the lower limit of 1.5, astigmatism in meridional direction in the vicinity of a relative angle of view of 0.7 becomes large and thus, excellent image forming performance cannot be obtained. On the other hand, when the ratio of the

condition (1) exceeds the upper limit of 3.0 or the ratio of the condition (2) exceeds the upper limit of 3.5, distortion at a wide angle end assumes a large negative value and thus, cannot be corrected.

The condition (3) relates to the air space d2 between the first concave lens and the first double convex lens in the first lens group 1. When the ratio (d2/f1) of the condition (3) falls out of the lower limit of 0.2, refracting power of the first concave lens and the first double convex lens of the first lens group 1 becomes excessively large, so that astigmatism and distortion in the visibility of the wide angle end cannot be corrected in well-balanced manner. On the contrary, when the ratio of the condition (3) exceeds the upper limit of 0.8, it is difficult to make the entire system compact and it is impossible to reduce diameter of the first concave lens of the first lens group 1. As a result, the entire system cannot be made compact or light.

In the wide angle aspherical zoom lens according to the first embodiment of the present invention, one concrete example satisfying the conditions (1) to (3) is shown in Table 1 below.

Table 1

f = 5.200-40.062 F/No.= 1.47-2.29					
Lens group	i of i-th surface	r	d	n	ν
1	1	-438.717	2.00	1.60311	60.7
	2	40.135	9.80		
	3	49.581	4.30	1.51633	64.1
	4	-139.707	0.20		
	5	41.629	0.90	1.80518	25.4
	6	21.035	5.85	1.58913	61.2
	7	-92.085	0.15		
	8	16.090	2.55	1.60311	60.7
	9	28.707	Variable		
2	10	17.510	0.70	1.69680	55.6
	11	5.792	3.47		
	12	-7.798	0.70	1.67003	47.2
	13	7.798	2.65	1.80518	25.5
	14	-340.780	Variable		
3	15	14.582	2.92	1.60602	57.4
	16	-41.160	Variable		
4	17	29.411	0.70	1.84666	23.9
	18	9.200	4.37	1.66547	55.2
	19	-17.766	Variable		
5	20	∞	6.30	1.51633	64.1
	21	∞	-		

In Table 1, character r denotes radius of curvature of a surface of each of the lenses of the zoom lens, character d denotes thickness of each of the lenses of zoom lens or air space between the lenses, character n denotes refractive index for d-line of each of the lenses of the zoom lens, character ν denotes Abbe number for d-line of each of the lenses of the zoom lens, character f denotes focal length at the wide angle end and a telephoto end of the zoom lens and character F/No. denotes F-number at the wide angle end and the telephoto end of the zoom lens.

Meanwhile, contour of the aspherical surface is defined by the following equation:

$$Z = C \cdot Y^2 / \{1 + \sqrt{1-(1+K) \cdot C^2 \cdot Y^2}\} + D \cdot Y^4 + E \cdot Y^6 + F \cdot Y^8 + G \cdot Y^{10} + H \cdot Y^{12} + I \cdot Y^{14}$$

where Z denotes a distance between a vertex of the aspherical surface and a point on the aspherical surface when height of the point from the optical axis A is expressed by Y, character C denotes a curvature of the vertex of the aspherical surface, character K denotes a conical constant and character D to I denote aspherical coefficients.

In Table 1, the 15th, 16th and 19th surfaces are aspherical and the conical constant K and the aspherical coefficients D to I of these surfaces are shown in Table 2 below.

Table 2

	15th surface	16th surface	19th surface
K	-2.62041E-1	-6.55280E+1	-9.74558E-2
D	1.20363E-5	3.50783E-5	1.89064E-5
D	-3.02701E-6	-2.39152E-6	3.52251E-6
F	3.43684E-9	-1.00707E-8	-1.27121E-7
G	-4.80097E-10	-1.60456E-10	2.17729E-9
H	3.91467E-12	2.68262E-12	-8.10168E-12
I	1.16381E-13	8.36613E-14	-2.28223E-13

Then, as examples of the air space variable by zooming, values of the air space obtained at the time when an object point is disposed at infinite distance from the zoom lens, values of the air space obtained at the time when the object point is disposed at a distance of 1.4m from the surface r1 of the first lens group 1 and values of the air space obtained at the time when the object point is disposed at a distance of 0.7m from the surface r1 of the first lens group 1 are, respectively, shown in Tables 3, 4 and 5 below. In Tables 3 to 5, the indication "Standard" means a standard position representing a zoom position where the fourth lens group 4 comes closest to the third lens group 3 for each position of the object point.

Table 3

	Wide angle	Standard	Telephoto
f	6.110	24.311	47.991
d9	1.000	12.300	16.312
d14	17.824	6.524	2.512
d16	5.122	1.579	5.122
d19	2.000	5.534	2.000

Table 4

	Wide angle	Standard	Telephoto
f	6.108	25.838	47.013
d9	1.000	12.700	16.312
d14	17.824	6.124	2.512
d16	5.102	1.258	3.922
d19	2.020	5.864	3.200

Table 5

	Wide angle	Standard	Telephoto
f	6.105	28.043	46.170
d9	1.000	13.230	16.312
d14	17.824	5.594	2.512
d16	5.083	0.907	2.846
d19	2.039	6.215	4.276

Figs. 3, 4 and 5 show aberrations at the wide angle end, the standard position and the telephoto end of the wide angle aspherical zoom lens shown in Table 1, respectively and exhibit excellent optical performance of the zoom lens of Table 1.

In this embodiment, the convex lens of the fourth lens group 4 has the aspherical surface r19. However, it is needless to say that the present invention is also applicable to a case in which the concave lens of the fourth lens group 4 has at least one aspherical surface.

Values of a wide angle aspherical zoom lens according to a second embodiment of the present invention are shown in Table 6 below. Since the lens arrangement of this zoom lens is similar to that of Fig. 1 of the zoom lens according to the first embodiment of the present invention, description thereof is abbreviated for the sake of brevity.

In Table 6, the 5th-11th lenses counted from the side of the object and intervals between neighboring ones of these lenses are the same as those shown in Table 1.

Table 6

f = 5.200-40.047 F/No. = 1.47-2.29					
Lens group	i of i-th surface	r	d	n	ν
1	1	-159.394	2.00	1.60311	60.7
	2	52.509	10.20		
	3	64.491	4.00	1.51633	64.1
	4	-113.286	0.20		
	5	40.103	1.00	1.80518	25.4
	6	20.643	6.00	1.58913	61.2
	7	-92.085	0.15		
(The remaining portion is the same as Table 1)					

Figs. 6, 7 and 8 show aberrations at the wide angle end, the standard position and the telephoto end of the wide angle aspherical zoom lens shown in Table 6 and exhibit excellent optical performance of the zoom lens of Table 6.

Referring to Fig. 9, there is shown a wide angle aspherical zoom lens according to a third embodiment of the present invention.

Table 7

f = 5.000-38.521 F/No. = 1.47-2.29					
Lens group	i of i-th surface	r	d	n	ν
1	1	-96.865	2.00	1.60311	60.7
	2	61.868	13.42		
	3	67.112	5.00	1.51633	64.1
	4	-67.112	0.20		
	5	40.950	1.20	1.80518	25.4
	6a	21.095	0.04		
	6b	21.241	6.20	1.58913	61.2
	7	-169.025	0.20		
(The remaining portion is the same as Table 1)					

Values of the zoom lens of Fig. 9 are shown in Table 7 above. In Table 7, the 5th-11th lenses counted from the side of the object and intervals between neighboring ones of these lenses are the same as those shown in Table 1.

The zoom lens of Fig. 9 is structurally different from that of Fig. 1 in that the second concave lens and the second double convex lens of the first lens group 1 are formed into the cemented lens in Fig. 1, while the second concave lens and the second double convex lens of the first lens group 1 are provided separately from each other in Fig. 9.

Meanwhile, Figs. 10, 11 and 12 show aberrations at the wide angle end, the standard position and the telephoto end of the wide angle aspherical zoom lens shown in Table 7, respectively and exhibit excellent

optical performance of the zoom lens of Table 7.

Fig. 13 shows a video camera 100 according to the present invention. The video camera 100 includes at least a wide angle aspherical zoom lens 51 of the present invention, an imaging device 52, a signal processing circuit 53 and a viewfinder 54.

Claims

1. A wide angle aspherical zoom lens comprising sequentially from a side of an object:

   a first lens group which has a positive refracting power and is fixed relative to an image surface;

   a second lens group which has a negative refracting power and is movable on an optical axis of said wide angle aspherical zoom lens so as to have a magnification changing function;

   a third lens group which has a positive refracting power and is fixed relative to the image surface so as to have a light converging function; and

   a fourth lens group which has a positive refracting power and is movable on the optical axis such that the image surface displaceable in response to travel of said second lens group and movement of the object is fixed at a position spaced a predetermined distance from a reference surface;

   wherein a relatively large air space is provided between said third and fourth lens groups;

   wherein when viewed sequentially from the side of the object, said first lens group is constituted by a first concave lens, a first double convex lens, a second concave lens, a second double convex lens and a meniscus convex lens, said second lens group is constituted by a meniscus concave lens, a double concave lens and a convex lens, said third lens group is constituted by a single lens having at least one aspherical surface and said fourth lens group is constituted by a concave lens and a convex lens at least one of which has at least one aspherical surface.

2. A wide angle aspherical zoom lens as claimed in Claim 1, wherein in said first lens group, said first concave lens has a concave surface confronting the image surface, said second concave lens is a meniscus concave lens having a concave surface confronting the image surface, said meniscus convex lens has a concave surface confronting the image surface and a relatively large air space is provided between said first concave lens and said first double convex lens.

3. A wide angle aspherical zoom lens as claimed in Claim 2, which satisfies the following conditions (1) to (3):

   (1) $1.0 < r2/f1 < 3.0$
   (2) $1.5 < r3/f1 < 3.5$
   (3) $0.2 < d2/f1 < 0.8$

   where character $f1$ denotes a focal length of said first lens group, character $r2$ denotes a radius of curvature of one surface of said first concave lens of said first lens group, which surface confronts the image surface, character $r3$ denotes a radius of curvature of one surface of said first double convex lens of said first lens group, which surface confronts the object and character $d2$ denotes the air space between said first concave lens and said first double convex lens in said first lens group.

4. A video camera including a wide angle aspherical zoom lens, an imaging device, a signal processing circuit and a viewfinder, said wide angle aspherical zoom lens comprising sequentially from a side of an object:

   a first lens group which has a positive refracting power and is fixed relative to an image surface;

   a second lens group which has a negative refracting power and is movable on an optical axis of said wide angle aspherical zoom lens so as to have a magnification changing function;

   a third lens group which has a positive refracting power and is fixed relative to the image surface so as to have a light converging function; and

   a fourth lens group which has a positive refracting power and is movable on the optical axis such that the image surface displaceable in response to travel of said second lens group and movement of the object is fixed at a position spaced a predetermined distance from a reference surface;

   wherein a relatively large air space is provided between said third and fourth lens groups;

   wherein when viewed sequentially from the side of the object, said first lens group is constituted by a first concave lens, a first double convex lens, a second concave lens, a second double convex lens and a meniscus convex lens, said second lens group is constituted by a meniscus concave lens, a double concave lens and a convex lens, said third lens group is constituted by a single lens having at least one aspherical surface and said fourth lens group is constituted by a concave lens and a convex

lens at least one of which has at least one aspherical surface;

wherein in said first lens group, said first concave lens has a concave surface confronting the image surface, said second concave lens is a meniscus concave lens having a concave surface confronting the image surface, said meniscus convex lens has a concave surface confronting the image surface and a relatively large air space is provided between said first concave lens and said first double convex lens;

said wide angle aspherical zoom lens satisfying the following conditions (1) to (3):

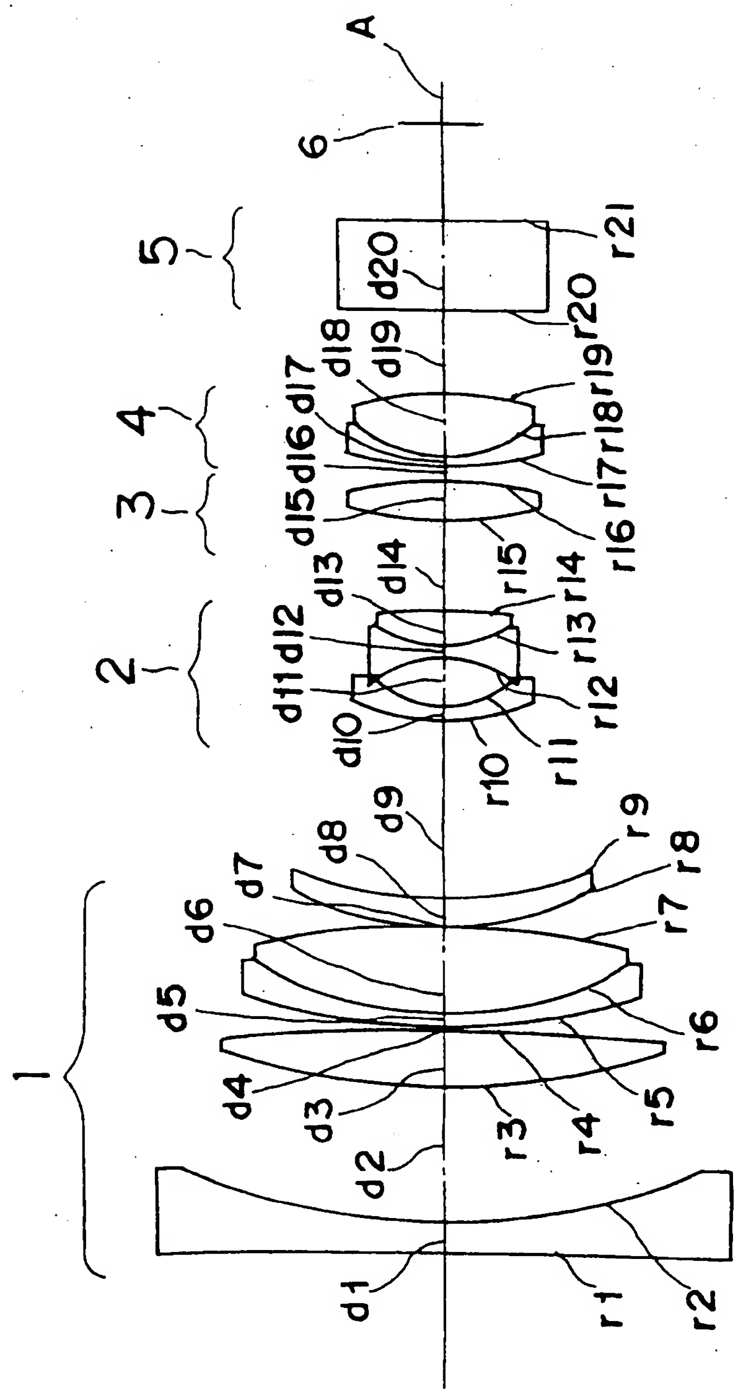
(1) $1.0 < r2/f1 < 3.0$

(2) $1.5 < r3/f1 < 3.5$

(3) $0.2 < d2/f1 < 0.8$

where character f1 denotes a focal length of said first lens group, character r2 denotes a radius of curvature of one surface of said first concave lens of said first lens group, which surface confronts the image surface, character r3 denotes a radius of curvature of one surface of said first double convex lens of said first lens group, which surface confronts the object and character d2 denotes the air space between said first concave lens and said first double convex lens in said first lens group.

Fig. 1


A
6
5
4
3
2
1
d1
d2
d3
d4
d5
d6
d7
d8
d9
d10
d11
d12
d13
d14
d15
d16
d17
d18
d19
d20
r1
r2
r3
r4
r5
r6
r7
r8
r9
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r13
r14
r15
r16
r17
r18
r19
r20
r21

Fig. 2 PRIOR ART

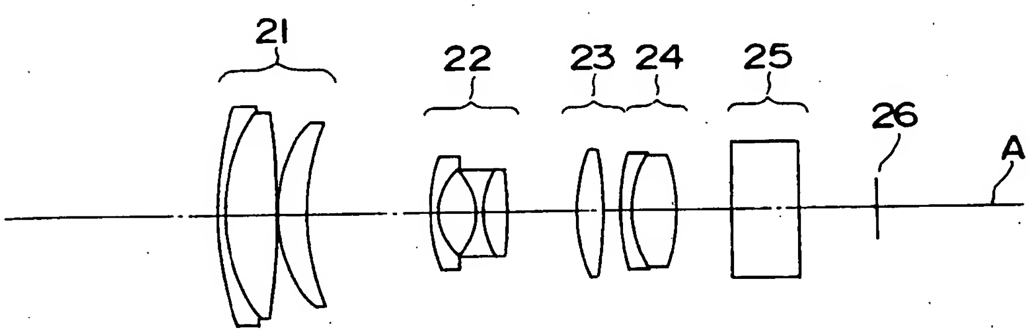


Fig. 3 (f = 5.200)

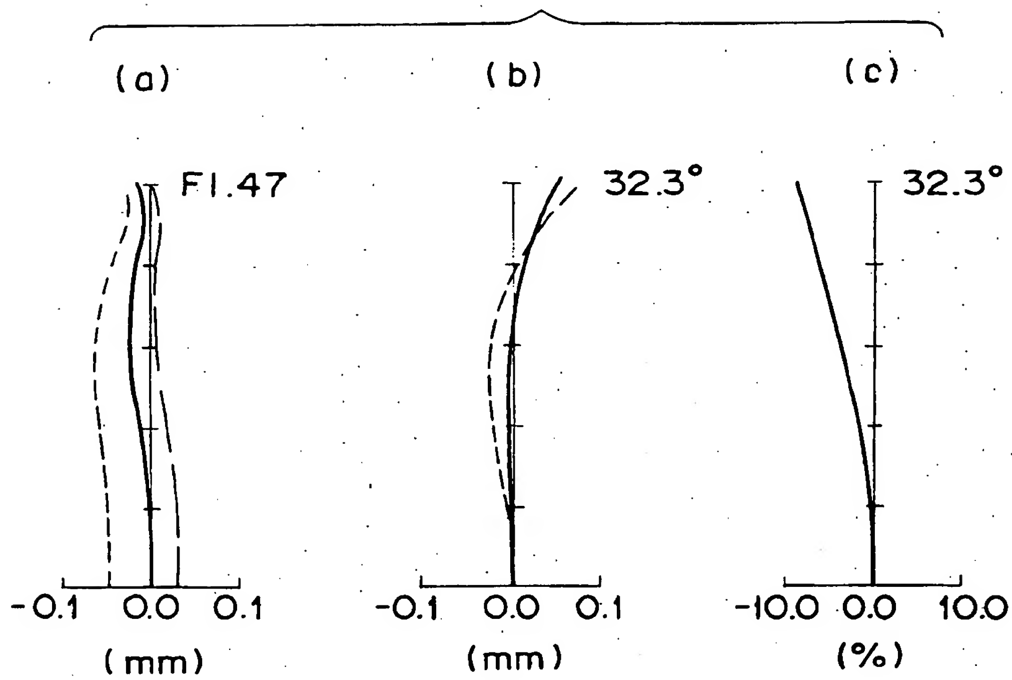


Fig. 4 (f = 22.016)

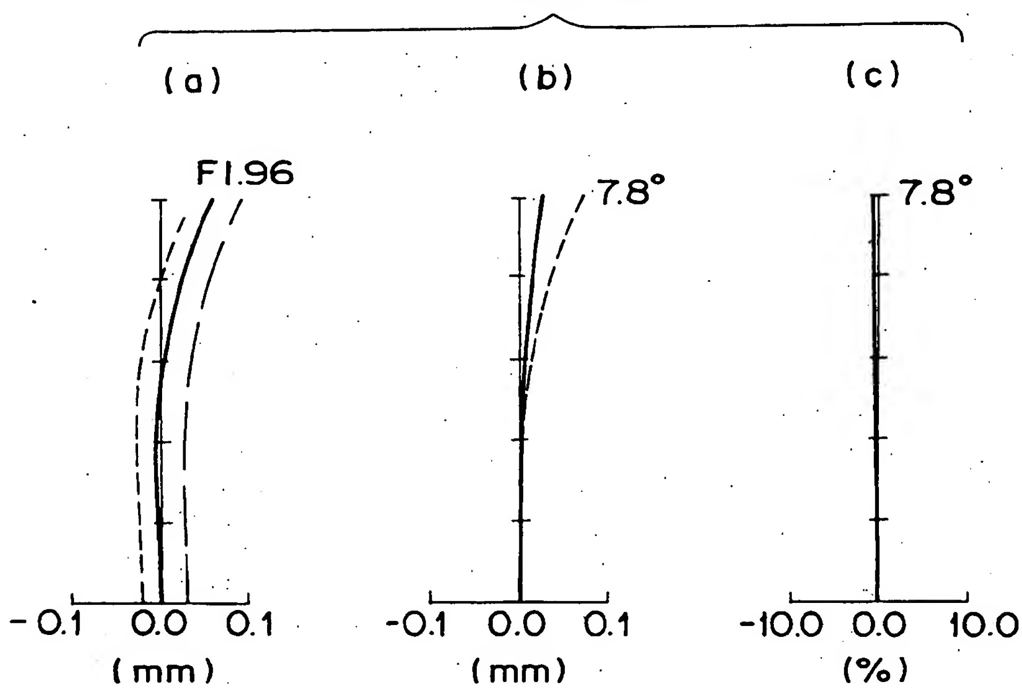


Fig. 5 (f = 40.062)

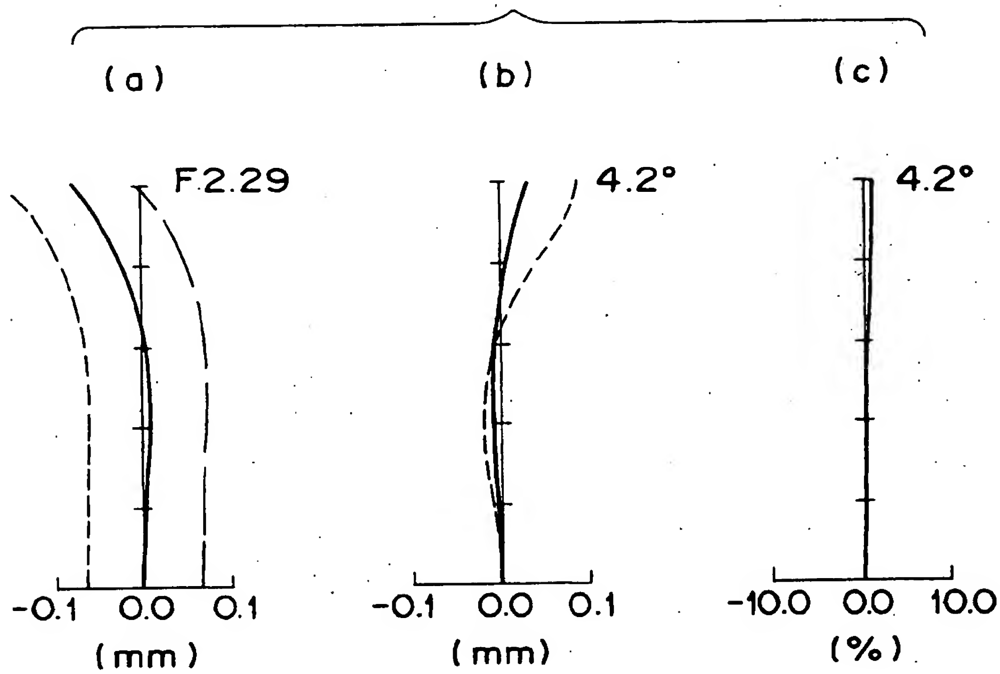


Fig. 6 (f = 5.200)

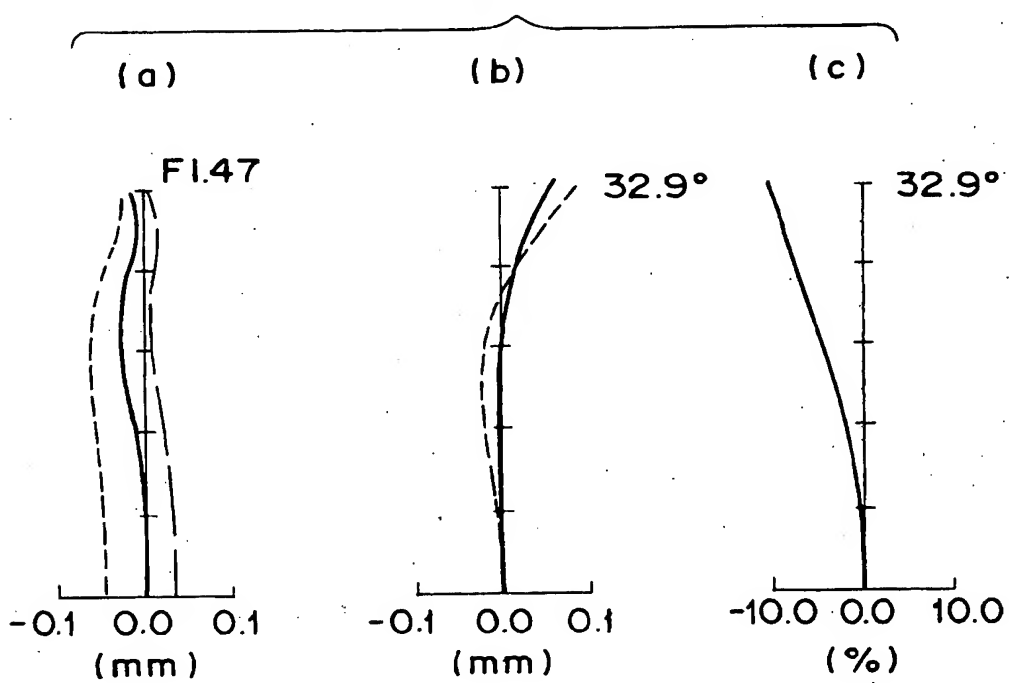


Fig. 7 (f = 22.008)

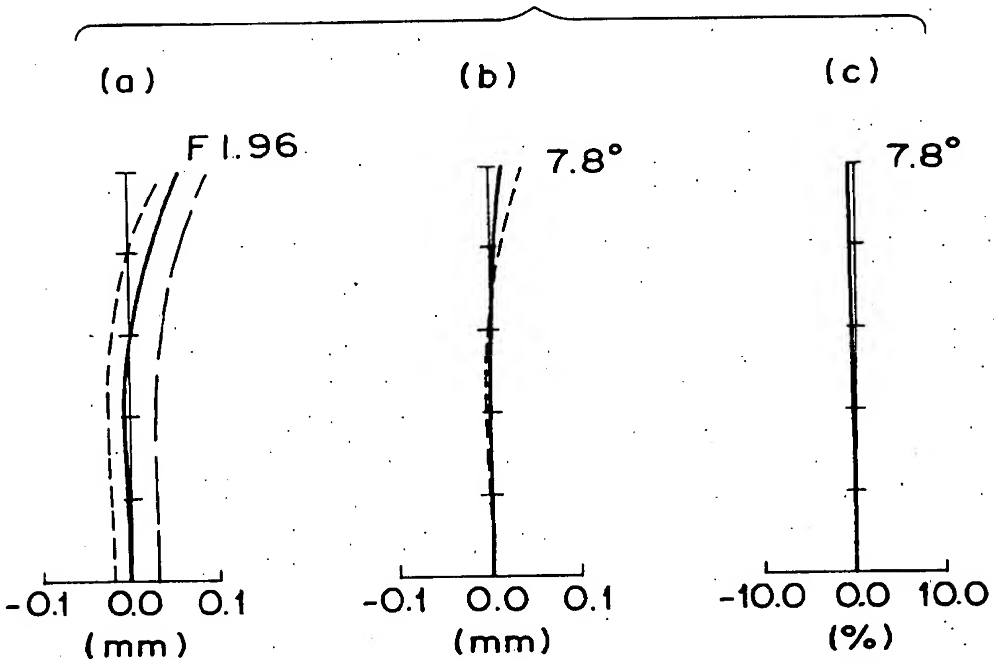


Fig. 8 (f = 40.047)

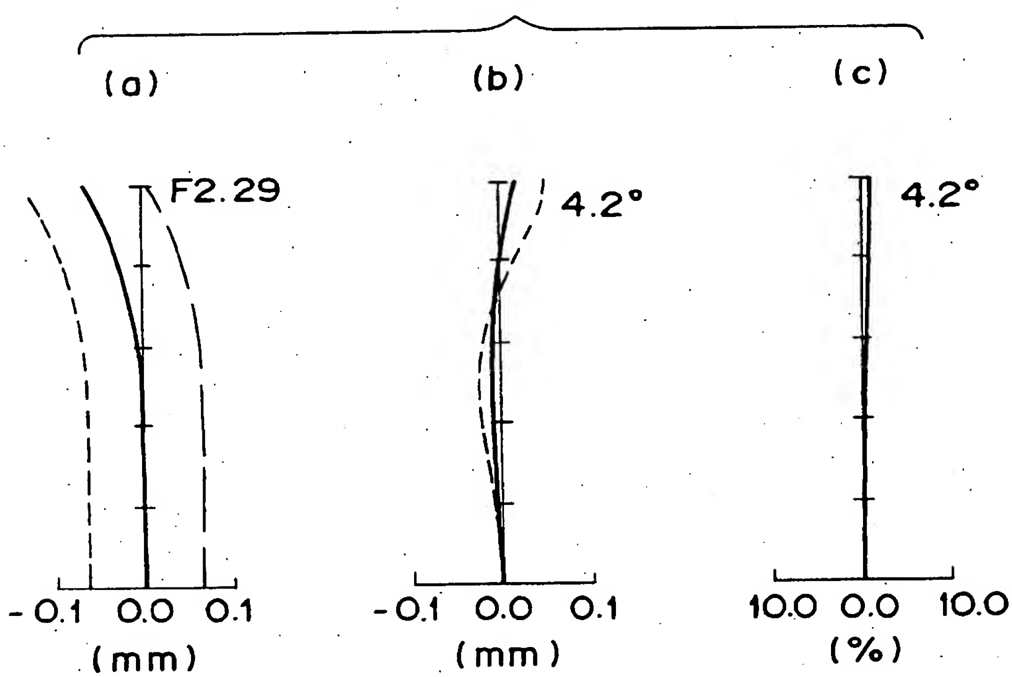
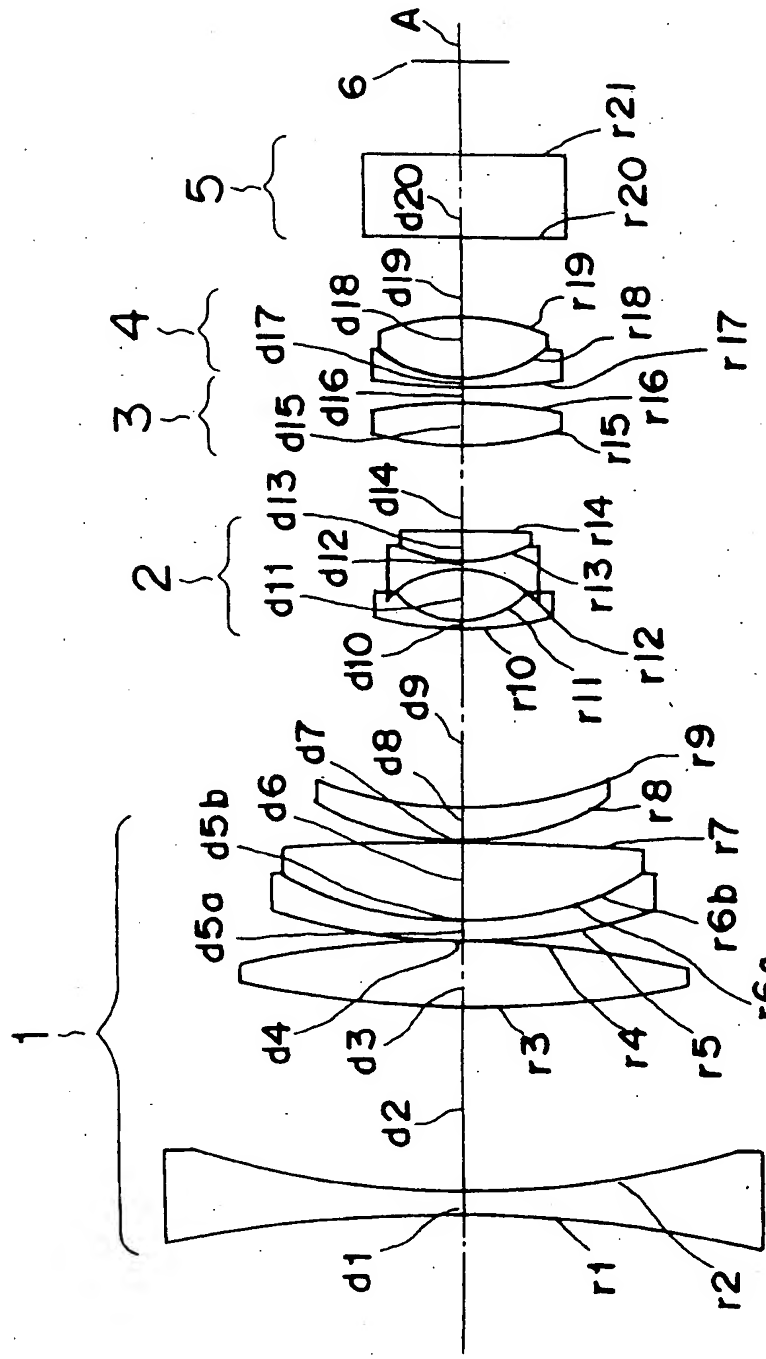


Fig. 9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r6a
r6b
r7
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r9
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r21

Fig. 10 (f = 5.000)

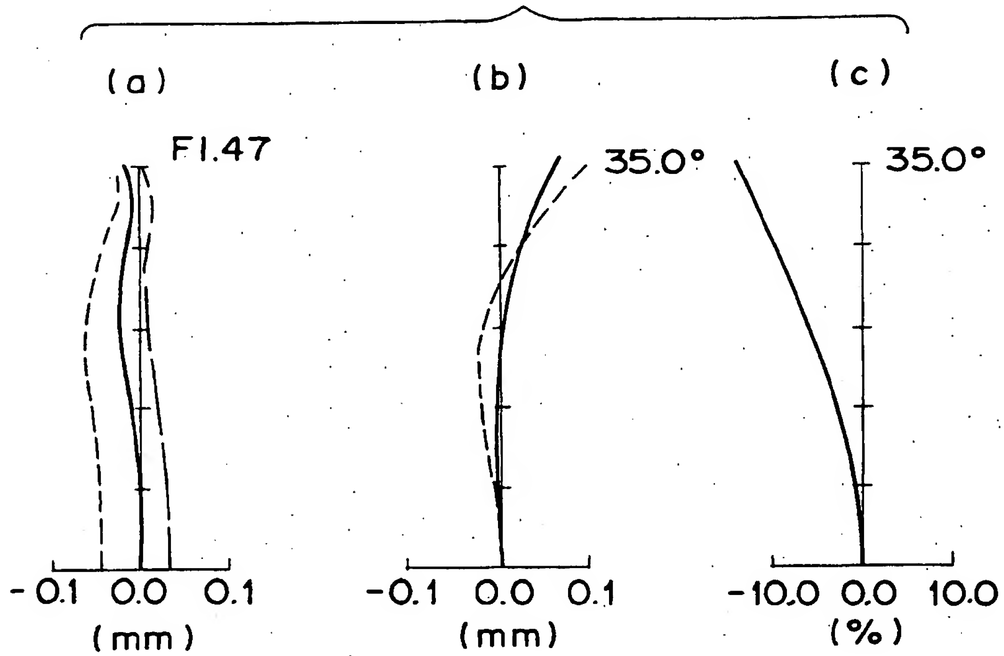


Fig. 11 (f = 21.169)

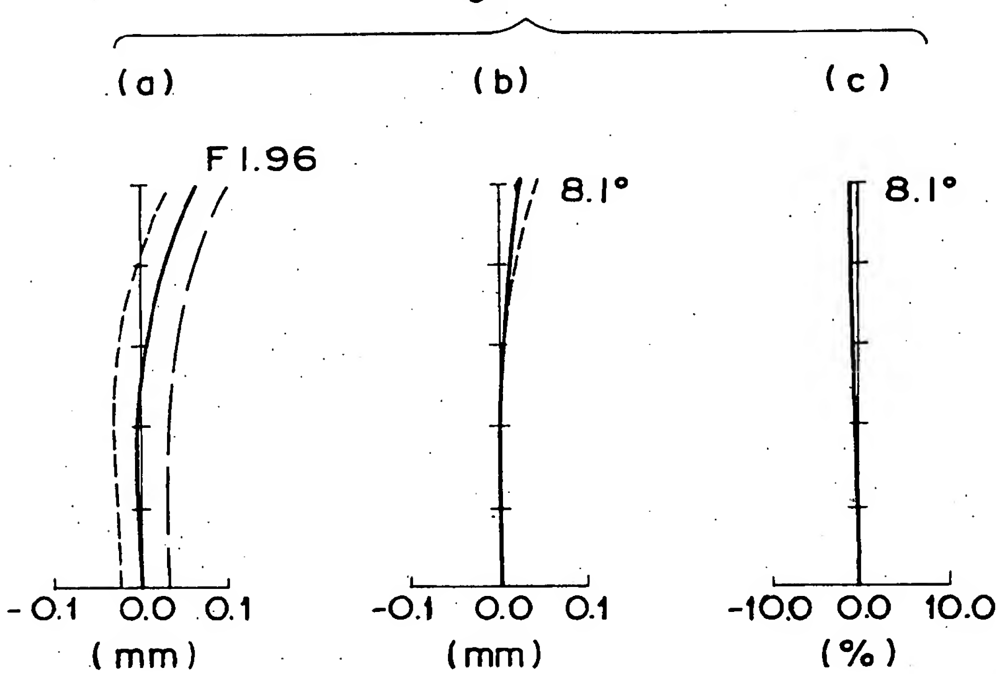


Fig. 12 (f = 38.521)

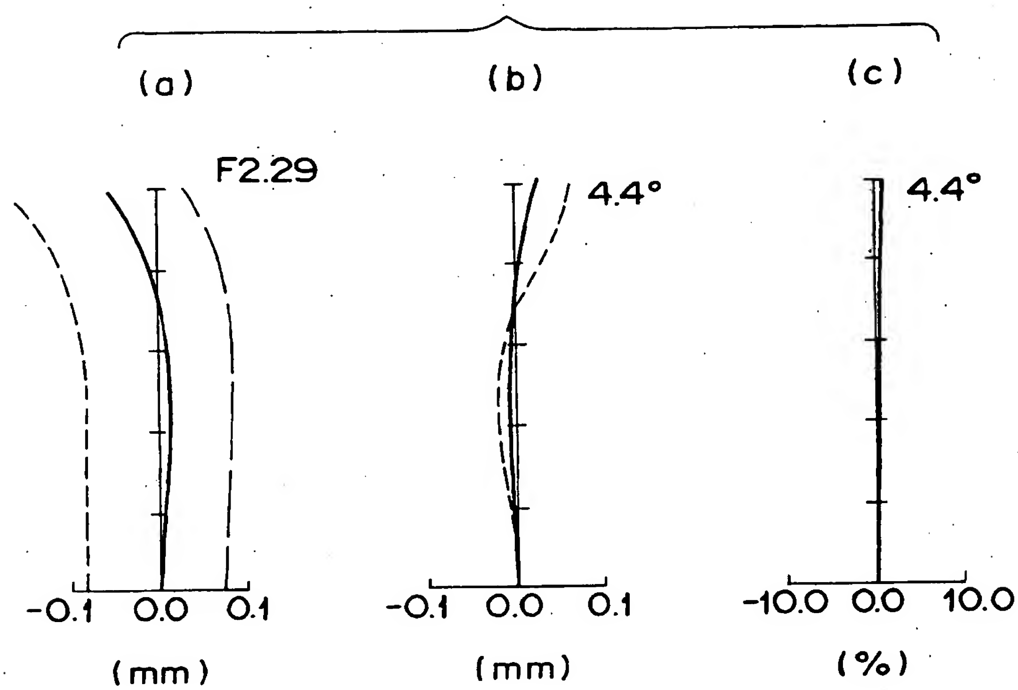
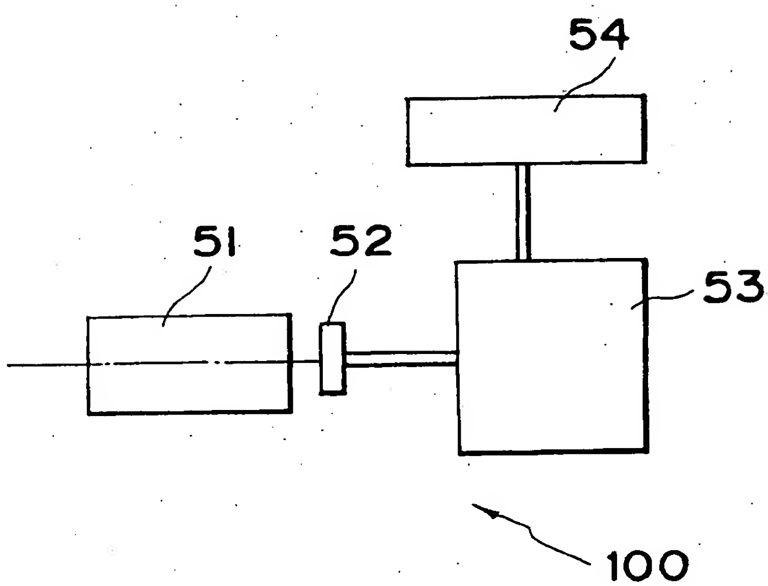


Fig. 13



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 5639

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 818 083 (MIHARA) * column 1, line 10 - column 3, line 13; figure 1 * ---	1,4	G02B15/173 G02B15/16
A	US-A-4 756 608 (T.ITOH) * abstract; figure 1 * * column 3, line 13 - line 20 * -----	1,2,4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	24 NOVEMBER 1992	VON MOERS F.

CATEGORY OF CITED DOCUMENTS

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